

Preface

The purpose of this book is to provide a sound introduction to the study of real-world phenomena that possess random variation. You will have met some ideas of probability already, perhaps through class experiments with coins, dice or cards, or collecting data for projects. You may well have met some named probability distributions, and be aware of where they arise. Such a background will be helpful, but this book begins at the beginning; no specific knowledge of probability is assumed.

Some mathematical knowledge is assumed. You should have the ability to work with unions, intersections and complements of sets; a good facility with calculus, including integration, sequences and series; an appreciation of the logical development of an argument. And you should have, or quickly acquire, the confidence to use the phrase “Let X be . . .” at the outset, when tackling a problem.

At times, the full story would require the deployment of more advanced mathematical ideas, or need a complex technical argument. I have chosen to omit such difficulties, but to refer you to specific sources where the blanks are filled in. It is not necessary fully to understand *why* a method works, the first time you use it; once you feel comfortable with a technique or theorem, the incentive to explore it further will come. Nevertheless, nearly all the results used *are* justified within this book by appeal to the background I have described.

The text contains many worked examples. All the definitions, theorems and corollaries in the world only acquire real meaning when applied to specific problems. The exercises are an integral part of the book. Try to solve them

before you look at the solutions. There is generally no indication of whether an exercise is expected to be straightforward, or to require some ingenuity. But all of them are “fair”, in the sense that they do not call on techniques that are more advanced than are used elsewhere within the book. The text chapters have their natural order, but it is not necessary to assimilate *all* the material in Chapter n before embarking on Chapter $n + 1$. I suspect that many readers will find Chapter 6 markedly harder than the earlier ones; so that has a Summary, for ease of recall. You can come to grips with the subtleties of the different modes of convergence later. My excuse for including some of the results about fluctuations in random walks in Chapter 7 is their sheer surprise; some proofs here are more sophisticated.

No-one writes a textbook from scratch. We rely on our predecessors who have offered us their own insights, found a logical pathway through the material, given us their examples. Every serious probability text since 1950 has been influenced by William Feller’s writings. In addition, it is a pleasure to acknowledge in particular the books by Geoffrey Grimmett and David Stirzaker, by Charles Grinstead and Laurie Snell, and by Sheldon Ross, that are cited in the bibliography. I also value *The Theory of Stochastic Processes*, by David Cox and Hilton Miller, and Sam Karlin’s *A First Course in Stochastic Processes*, which were standard texts for many years.

I thank many people for their witting and unwitting help. Without the guidance of David Kendall and John Kingman, I might never have discovered how fascinating this subject is. Among my Sussex colleagues, conversations with John Bather and Charles Goldie have cleared my mind on many occasions. I also appreciate the discussions I have had with successive cohorts of students; listening to their difficulties, and attempting to overcome them, has helped my own understanding. Springer’s referees have made useful comments on my drafts. I gave what I fondly hoped was the final version to Charles Goldie, who not only reduced the number of blunders, but made copious suggestions, almost all of which I have taken up. Mark Broom too found errors and obscurities, and the final text owes much to both of them. All the errors that remain are my responsibility. Without the help from two local TeX gurus, James Foster and James Hirschfeld, I would never have embarked on this project at all. Springer production staff (Stephanie Harding, Stephanie Parker and Karen Borthwick) have always responded helpfully to my queries. The patience and understanding of my wife Kay, during those long periods of distraction while I fumbled for the right phrase and the right approach, have been beyond what I could reasonably expect.

I seek to maintain an updated file of corrections, both to the solutions and to the text, at <http://www.maths.sussex.ac.uk/Staff/JH/ProbabilityModels.html>. For each correction, the first person to notify me at J.Haigh@sussex.ac.uk will

be offered the glory of being named as detector. I welcome feedback, from students and teachers; changes made in any subsequent editions because of such comments will be acknowledged.

Brighton, UK
November 2001

John Haigh

Preface to the Second Edition

This edition does not differ substantially from the original. Chapter 4 amplifies the account of distribution functions, and two extra Examples present illuminating applications of the idea of conditional expectation. An extra Section in Chapter 5 now contains much more material on ways of simulating from continuous random variables, with added exercises; and order statistics are introduced. Accounts of variance-reduction and variance-stabilizing methods have been inserted. In Chapter 7, the presentation of Parrondo's Paradox has been recast. Every time a logarithm arises, it is a natural logarithm, i.e. the base is e . In the first edition, $\ln$ and $\log$ were used interchangeably, but for consistency $\ln$ has been replaced throughout by $\log$.

I am pleased to name Dr. Bharath, Carole Becker, Jorge Garcia, Hank Krieger, Jordan Stoyanov and Neil Walker as sleuths who identified errors, now corrected, in the original text. For any further corrections or clarifications, contact me at J.Haigh@sussex.ac.uk.

I have sought to follow the advice of my colleague James Hirshfeld on improving the layout, specifically on reducing the number of times a mathematical formula wraps round onto the next line in the main text. And I am particularly grateful to Emyr James for rescuing what appeared to be a file beyond repair.

I thank Joerg Sixt and his Springer colleagues for encouraging me to make these changes. Probability is a huge and thriving area of mathematics, and I am conscious that, despite this additional material, many important topics have had to be omitted, for reasons of space. I hope that the spirit of William

Feller – that the applications of probability are far-reaching and fascinating – shines.

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